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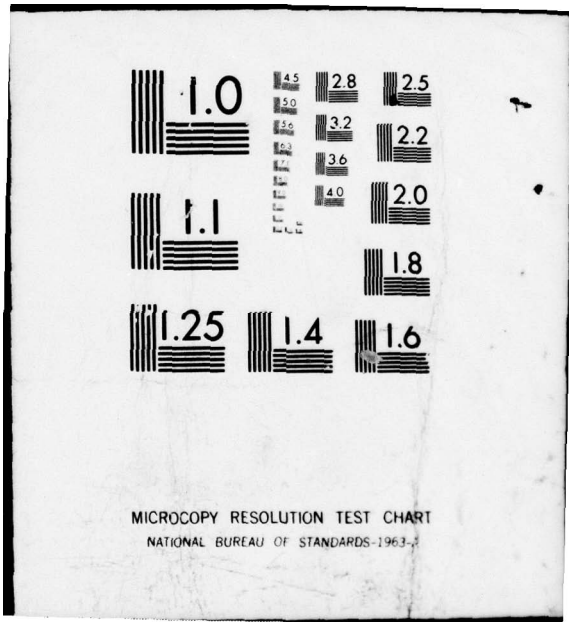
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AIR FORCE HUMAN RESOURCES LABORATORY

VALIDATION OF NON-VERBAL MEASURES FOR SELECTION AND CLASSIFICATION OF ENLISTED PERSONNEL

By

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December 1976
Final Report for Period June 1973 – November 1976

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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This final report was submitted by Personnel Research Division, Air Force Human Resources Laboratory, Lackland Air Force Base, Texas 78236, under project 7719, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235. Mr. James M. Wilbourn, Personnel Research Division, was the principal investigator.

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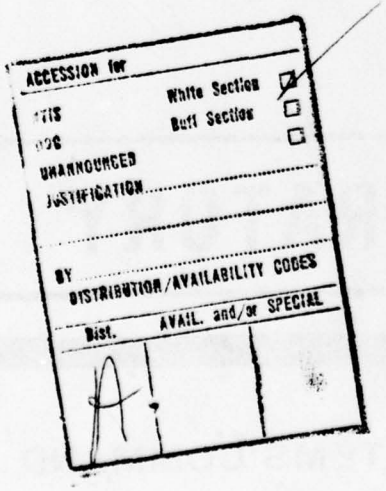

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A non-verbal aptitude battery was administered to 13,584 non-prior-service male basic airmen. Additional aptitudinal and educational data were combined with the non-verbal tests to assess their usefulness in predicting final technical school grade. Although the correlations between the individual subtests and final school grade (FSG) were not found to be statistically significant in every technical course, figure analogies and dial reading appear to demonstrate the highest relationship with FSG. The multiple correlations based on a composite of all non-verbal subtests reached statistical significance in over 75% of the technical areas in both the total sample and lower ability subgroups, and the composite was found to make an unique and significant contribution to the prediction of FSG over and above the Armed Forces Vocational Aptitude Battery (ASVAB–3) Selector Aptitude Index (AI) alone.

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When additional aptitudinal and educational data were added to the composite, the predictive efficiency of the composite increased. These findings substantiate the validity of the non-verbal test measures and the potential utility of including these measures in future operational test batteries.

PREFACE

This work was conducted under project 7719, Air Force Personnel System Development on Selection, Assignment, Evaluation, Quality Control, Retention, Promotion, and Utilization; task 771909, Development and Validation of Specialized Procedures to Improve Personnel Classification and Assignment.

This research was accomplished in support of RPR-73-17, Non-Verbal Aptitude Assessment, for ATC/XPTT (Capt Curran).

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I. INTRODUCTION

The selection and classification of Air Force personnel have been dependent upon traditional paper-and-pencil tests for many years. Based on the enlistees' test results, interests, and Air Force needs at the time, an assignment to a particular career area or job is made depending on the prerequisite qualifications for such assignment. For some time, there has been a growing concern as to whether these conventional aptitude measures and the scores derived from these tests accurately reflect an individual's capability or potential. Such aptitude tests measure a limited portion of an individual's mental abilities, namely those implicit in verbal skills, and have ignored other types of abilities and problem solving skills. In addition, numerous factors have been identified as having an adverse effect on scores from traditional tests: lack of motivation, poor educational opportunities, limited exposure to various news and information media, reading disability, and inadequacies in the family's educational, cultural, social, and economic background (Anastasi, 1968; Freeberg, 1970; Haggard, 1952).

As early as 1941, non-verbal aptitude measures were being developed in an effort to provide tests suitable for individuals with limited reading skills and/or lower levels of intellectual ability (Cattell, 1950; Pintner, 1945; Porteus, 1950; Raven, 1941). Such tests developed to meet this include Raven's "Progressive Matrices," 1941; Cattell's "Culture-Fair Intelligence Test," 1940; "The Davis-Eells Game Test," 1953; "The Leiter Performance Scale," 1940; and the "Goodenough-Harris Drawing Test," 1963.

In the military setting, one of the initial efforts to test illiterate or disadvantaged personnel resulted in development of the "Army Beta" during World War I (Yerkes, 1921). Other governmental agencies, both federal and state, have attempted to develop non-verbal test measures in lieu of more verbal measures. One example is the development of the non-reading edition of the General Aptitude Test Battery (GATB) developed by the U.S. Employment Service. This version of the GATB is used to measure the aptitude of job applicants and candidates for occupational training who have previously had a meager or unsuccessful experience with tests of a more verbal nature (U.S. Department of Labor, 1968).

In general, non-verbal tests have not been found to correlate well with verbal measures of intelligence or with academic-type criteria (Rulon, 1950). However, in an Army study, Maier (1971) found that although non-verbal tests did not form an independent and separate cluster from verbal tests, the relationship between verbal and non-verbal tests appeared to be dependent upon the specific test content of the non-verbal measures. For example, some non-verbal tests such as shop mechanics were closely related to mechanical-type tests with little verbal content; on the other hand, radio code, clerical speed, and pattern analysis were found to be more closely related to academic-type tests. Regardless of the relationship reported between verbal and non-verbal tests, it is generally recognized that non-verbal measures are extremely valuable in providing additional unique information concerning an individual's capabilities (Anastasi, 1968). In an Air Force study, Wilbourn (1973) found that non-verbal tests, when added to the selector aptitude indexes (Mechanical, Administrative, General, Electronics), added a significant and unique contribution to the prediction of technical training school success. He concluded that the use of non-verbal tests, as well as other aptitudinal and educational data, could make a significant contribution if added to the Air Force operational selection and classification battery.

The problem of economic utilization of manpower has become increasingly important with the all-volunteer force structure. The objective of the Air Force classification and assignment system is to optimize the assignment of personnel to particular career areas where their talents and abilities match those required by the job. This objective is no less important for those who demonstrate lower levels of ability as measured by traditional paper-and-pencil tests. In an effort to estimate the abilities of lower level personnel more accurately, this study relates performance on a non-verbal test to performance in technical training. The usefulness of these tests along with additional aptitudinal and educational data was also evaluated in an effort to refine and improve the selection and classification procedures currently used by the Air Force.

II. METHOD

The sample population consisted of 13,584 non-prior service male basic airmen tested during the period 3 August 73 through 15 August 75. The sample was divided into 34 subgroups based on the initial technical training course to which they were assigned. The technical training courses used for validation analyses and the number of subjects in each career area are listed in Table 1. Since one of the objectives of this study was to assess the usefulness of non-verbal tests among lower ability personnel, specific analyses were included for the lower mental ability categories. Lower mental ability personnel include those individuals who are classified as Category III and IV based on their percentile scores of 10 through 64 on

Table 1. **Sample Population by Air Force Specialty Code**

AFSC	Title	Sel AI	Total N[a]	Cat III & IV N[b]
25231	Weather Observer	G-80	145	
27230	Air Traffic Control Operator	A/G-60	390	173
29130	Telecommunications Operations Specialist	A/G-60	143	
30332	AC&W Radar Repairman	E-80	99	
30430	Radio Relay Equipment Repairman	E-80	138	
30434	Ground Radio Communications Equipment Repmn	E-80	275	
32231	Weapon Control Systems Mechanic	E-80	145	
32830	Avionics Communications Specialist	E-80	100	
32833	Electronic Warfare System Specialist	E-80	126	
32834	Avionic Inertial and Radar Navigation Sys Spl	E-80	99	
42132	Acft Pneudraulic Repairman	M/E-40	132	98
42133	Aerospace Ground Equipment Repairman	M/E-40	450	365
43131	Aircraft Maintenance Specialist	M/E-50	2,295	1,499
43230	Jet Engine Mechanic	M-40	742	503
44330	Missile Mechanic	M-50	162	114
46130	Munitions Maintenance Specialist	M/E-60	569	368
46230	Weapons Mechanic	M/E-60	610	389
53430	Airframe Reapir Specialist	M-40	196	128
54330	Electrical Power Production Specialist	M/E-50	214	160
57130	Fire Protection Specialist	G-40	388	265
60530	Air Passenger Specialist	A-50	121	
60531	Air Cargo Specialist	M-50	350	233
62230	Food Service–Cook	G-40	112	
63130	Fuel Specialist	G/M-40	305	241
64530	Inventory Management Specialist	A/G-60	669	409
64730	Materiel Facilities Specialist	G-60	229	184
70230	Administrative Specialist	A-40	724	579
73230	Personnel Specialist	A-60	213	137
81130	Security Specialist	G-40	1,996	1,428
81230	Law Enforcement Specialist	G-50	601	335
90010	Medical Helper	G-60	352	178
90230	Medical Service Specialist	G-60	267	123
90630	Medical Administrative Specialist	G-60	116	
92230	Aircrew Life Support Specialist	G-40	111	

[a] Analyses on those AFSC samples of less than 150 were not cross-validated.

[b] Those AFSCs with blanks inserted did not contain a sufficient number of subjects for separate Category III/IV analyses.

the Armed Forces Qualification Test (AFQT). Of the 34 career areas, 21 had a sufficient number of Category III and IV personnel to allow separate analyses for these subgroups alone. When sufficient numbers of enlistees (N = 150 or more) were available, the technical course subgroups were further divided into random halves for validation and cross-validation analyses.

All subjects were administered the Non-Verbal Aptitude Battery – Revised (NVAB-R) which consists of eight subtests described in Table 2. In addition, aptitudinal information (Armed Services Vocational Aptitude Battery – Form 3 [ASVAB-3] aptitude index scores, and AFQT percentile scores) was retrieved from airman record files maintained by the Personnel Research Division of the Air Force Human Resources Laboratory (AFHRL). Table 3 lists the subtest components for the four Selector Aptitude Indexes (AI) of the ASVAB-3. Criterion data (final technical school grades) were obtained from the tape files of the Computational Sciences Division of *AFHRL*.

Table 2. **Description of the Non-Verbal Aptitude Battery – Revised**

Title	Description	Number of Items	Time Limit (min)[a]
(1) Number Reversal	A measure of perceptual speed and accuracy in finding the exact reversal of a series of 1 to 7 digits	48	7
(2) Pattern Matching	A measure of abstract reasoning abilities comprised of pictorial problems which require the subject to select the part that completes a specified pattern among five alternatives.	38	20
(3) Dial Reading	A measure of numerical ability which requires the subject to read a dial quickly and accurately.	30	4
(4) Paired Letters	A measure of perceptual speed and clerical ability in finding a pair of letters or figures identical to the underlined pair in each item.	34	3
(5) Wheels.	A measure of mechanical reasoning in which the subject determines the turning direction of a series of wheels when the direction of one wheel in the series is given.	60	10
(6) Figure Analogies	A measure of abstract reasoning ability in which the subject is required to determine how figures can be alike.	30	10
(7) Card Patterns	A reasoning test comprised of pictorial problems using playing card suits arranged in patterns and series.	50	20
(8) Dominoes	A reasoning test comprised of pictorial problems of dominoes arranged in numeric patterns and series.	88	25

[a]Does not include instructions and sample items.

Table 3. **Subtests and Aptitude Composites Comprising the Armed Services Vocational Aptitude Battery – Form 3[a]**

Subtest	Number of Items	Subtest Composite for Aptitude Index			
		Mechanical	Administrative	General	Electronics
Coding Speed	100		X		
Word Knowledge	25		X	X	
Arithmetic Reasoning	25			X	X
Tool Knowledge	25	X			
Space Perception	25				X
Mechanical Comprehension	25	X			
Shop Information	25	X			
Automobile Information	25	X			
Electronics Information	25				X

[a]Effective July 1973 through September 1975.

Multiple linear regression analyses (Bottenberg & Ward, 1963) were used to determine the usefulness of the non-verbal tests, educational and aptitudinal data, both with and without the Selector AI in predicting final school grade (FSG). Table 4 describes the variables used in these analyses.

Table 4. **List of Variables**

Variables	Description
Predictor	
AFQT score	Continuous variable based on percentile score obtained on Armed Forces Qualifying Test (AFQT).
Aptitude indexes	Continuous variables based on percentile score obtained on Armed Services Vocational Aptitude Battery – Form 3 (ASVAB-3).
Educational level	Categorical variable with three categories: high school non-graduate, high school graduate, attended/graduated from college.
Non-verbal tests	Continuous variables based on raw scores obtained on each of the following non-verbal tests: number reversal, pattern matching, dial reading, paired letters, wheels, figure analogies, card patterns, and dominoes.
Selector Aptitude Index (AI)	Continuous variable based on percentile score on aptitude index used as prerequisite for entry into a particular career field.
Criterion	
Final school grade	Numeric grade assigned upon completion of technical training course.

III. RESULTS AND DISCUSSION

Validity of the Non-Verbal Tests

Table 5 presents the restricted correlations for the validation subgroups between each of the non-verbal tests and FSG criterion. To facilitate comparisons among the Air Force specialty codes (AFSCs), the training courses were categorized into six broad technical areas based on similarity of job duties and/or Selector AI level. The relationship between the eight subtests and the criterion varies widely among the technical areas. In 12 of the 34 courses, all eight subtests showed a statistically significant relationship. In

Table 5. **Correlations Between Non-Verbal Tests and Final Technical School Grade – Validation Sample – All Categories**

Area	AFSC	N	Non-Verbal Subtests							
			Number Reversal	Pattern Matching	Dial Reading	Paired Letters	Wheels	Figure Analogies	Card Patterns	Dominoes
Electronics	30332	99[a]	.09	.15	.02	.03	.03	.12	.01	.14
	30430	138[a]	.01	.05	.12	.03	.11	.02	.16*	.06
	30434	137	.05	.08	.01	.05	.06	.23**	.03	.22**
	32231	145[a]	.01	.11	.25**	.08	.11	.21**	.02	.09
	32830	100[a]	.09	.17	.08	.01	.02	.21*	.01	.24*
	32833	126[a]	.17*	.44**	.21*	.22*	.07	.36**	.15	.28**
	32834	99[a]	.00	.37**	.26**	.13	.33**	.45**	.25**	.21*
Mechanical	42132	132[a]	.20*	.30**	.35**	.20*	.29**	.38**	.12	.18*
	42133	225	.15*	.32**	.23**	.21**	.30**	.29**	.27**	.28**
	43131	1,147	.13**	.13**	.24**	.13**	.19**	.20**	.09**	.12**
	43230	371	.13**	.18**	.28**	.18**	.19**	.24**	.11*	.22**
	44330	81	.15	.26*	.14	.05	.25*	.34**	.20	.12
	46130	284	.20**	.22**	.26**	.13*	.19**	.22**	.15**	.19**
	46230	305	.01	.09	.11*	.04	.09	.10	.04	.04
	53430	98	.22*	.27**	.31**	.26**	.24*	.36**	.18	.36**
	54330	107	.11	.06	.01	.01	.05	.07	.21*	.02
Administrative	60530	121[a]	.18*	.16	.23*	.26**	.06	.26**	.19*	.22*
	60531	175	.15*	.22**	.31**	.22**	.24**	.28**	.16*	.28**
	64530	334	.08	.18**	.24**	.09	.11*	.21**	.11*	.08
	70230	362	.18**	.25**	.23**	.16**	.25**	.27**	.15**	.25**
	73230	106	.15	.18	.18	.01	.08	.17	.05	.02
Medical/Dental	90010	176	.34**	.36**	.41**	.33**	.35**	.37**	.18*	.25**
	90230	133	.22**	.30**	.41**	.41**	.34**	.40**	.24**	.27**
	90630	116[a]	.22*	.13	.32**	.15	.23**	.15	.11	.21*
Services/Supply	57130	194	.17*	.09	.20**	.21**	.16*	.20**	.12	.08
	62230	112[a]	.06	.02	.09	.17	.12	.03	.03	.16
	63130	152	.24**	.18*	.44**	.30**	.41**	.41**	.19*	.24**
	64730	114	.12	.10	.30**	.09	.18*	.21*	.07	.12
	81130	996	.18**	.18**	.26**	.21**	.24**	.22**	.12**	.31**
	81230	300	.14*	.16**	.28**	.17**	.25**	.17**	.12*	.33**
	92230	111[a]	.24**	.16	.18*	.17	.21*	.19*	.15	.13
Communications/Operations	25231	145[a]	.20*	.12	.26**	.16*	.20*	.17*	.02	.29**
	27230	195	.19**	.21**	.30**	.11	.03	.21**	.03	.07
	29130	143[a]	.32**	.25**	.28**	.24**	.20*	.26**	.22**	.35**

[a]AFSCs with insufficient N to cross-validate – total sample reported.

*Significant at or beyond .05 level.

**Significant at or beyond .01 level.

an additional 11 areas, a majority of the subtests (i.e., four to seven) also demonstrated significant relationships. On the other hand, in Personnel (73230), Food Service–Cook (62230), and two of the Electronics courses (30332, 30430), none of the non-verbal tests were found to be significantly related to the criterion. In general, it appears that a larger number of the subtests show significant relationships in the Mechanical specialties. In the Electronics area, the opposite trend is prevalent. No obvious trend appears between the Selector AI level required for course entry and the significance of the non-verbal/criterion relationships. Although no significant relationships were found in five of the E-80 Selector AI courses, significant correlations were noted in two other E-80 Electronics courses and the G-80 Weather course. Among the individual subtests, figure analogies and dial reading demonstrated substantial relationships in a majority of the technical training areas, while card patterns had the lowest number of statistically significant relationships across all the technical areas.

Results of the correlational analysis for lower mental ability personnel are presented in Table 6. Thirteen of the technical courses had an insufficient number of individuals to permit separate analyses of the low ability subgroup. In addition to the high Selector AI level courses (i.e., AI level = 80) where few, if any, Category III and IV personnel would qualify, five other AFSCs had to be deleted from these analyses. In the smaller subgroups containing only the lower categories, significant correlations between the non-verbal subtests and the criterion were less prevalent. In interpreting the results obtained in the lower ability level subgroups, it should also be realized that the small number of cases in several of the courses tend to make the relationships found somewhat unreliable. In only two of the technical training areas (Aerospace Ground Equipment Repair [42133] and Security Police [81130]) were the relationships between the non-verbal subtests and criterion found to be statistically significant for each of the subtests. Similar to the all-category subgroups, the two non-verbal subtests found to have the largest number of significant relationships across the technical training areas were dial reading and figure analogies. Those subtests showing the least relationship to the criterion were card patterns and number reversal. Although the correlations found among the lower category personnel appear somewhat attenuated, the validities of one or more of the non-verbal tests are of sufficient size to emphasize their potential usefulness in selection and classification instruments, particularly with the lower ability levels of enlisted accessions.

To determine the usefulness of the entire non-verbal battery, multiple correlations were computed for the non-verbal composite comprised of all eight subtests. These correlations are contained in Table 7 for both the all-category and lower category subgroups. For the all-category samples, the non-verbal composite was significantly related to FSG in 27 of the 34 technical training areas. There was no trend or similarity noted among the courses in which the non-verbal composite failed to reach the required significance level.

For the lower category personnel, the non-verbal composite was statistically significant in 16 of the 21 courses. Three of the courses in which non-significant correlations were noted were identical to the courses where non-significant correlations were found in the all-category samples (Missile Mechanic [44330], Personnel [73230], and Electrical Power Production [54330]).

To determine the stability of the non-verbal composites from one sample to another, a cross-validation procedure was utilized. Where sample size was sufficient, the population was randomly divided into two half-samples. Where the validation composites were significant, regression weights developed on half-sample 1 (validation sample) were then cross-applied to half sample 2 (cross-validation sample). The results are shown in Table 7, Column A/B, All Non-Verbal. Some shrinkage in the magnitude of the correlation coefficients was evidenced. Of the 21 courses permitting cross-application in the all-category samples, 18 maintained a level of significance. In the lower ability subgroups, three of the courses in which significant correlations were noted in the validation sample demonstrated non-significant relationships upon cross-validation. These somewhat spurious results found in the Category III and IV subgroups may be a result of the small sample size. Although the cross-validation results make the use of non-verbal measures doubtful in some areas, the fact that the non-verbal composite did reach and maintain a level of significance in both validation and cross-validation samples in a sizable number of courses indicates their potential usefulness as possible subtests in future revisions of operational tests.

Table 6. **Correlations Between Non-Verbal Tests and Final Technical School Grade – Validation Sample – Category III – IV**

Area	AFSC	N	Non-Verbal Subtests							
			Number Reversal	Pattern Matching	Dial Reading	Paired Letters	Wheels	Figure Analogies	Card Patterns	Dominoes
Electronics	30332	X[b]								
	30430	X								
	30434	X								
	32231	X								
	32830	X								
	32833	X								
	32834	X								
Mechanical	42132	98[a]	.17	.19*	.33**	.19*	.21*	.32**	.03	.03
	42133	182	.17*	.31**	.19**	.26**	.30**	.30**	.32**	.37**
	43131	749	.11**	.11**	.16**	.13**	.15**	.15**	.07*	.06
	43230	251	.10	.07	.17**	.11	.16**	.16**	.02	.16**
	44330	114[a]	.18*	.19*	.24**	.08	.18*	.23*	.16	.23*
	46130	193	.02	.00	.12	.01	.11	.08	.01	.21**
	46230	194	.04	.09	.14*	.05	.08	.13	.13	.05
	53430	128[a]	.13	.08	.13	.17*	.15	.22**	.07	.26**
	54330	80	.07	.04	.04	.06	.02	.01	.00	.07
Administrative	60530	X								
	60531	116	.10	.05	.32**	.24**	.08	.09	.12	.10
	64530	204	.12	.18**	.17*	.20**	.12	.24**	.23**	.08
	70230	289	.09	.11*	.17**	.06	.12*	.15**	.08	.18**
	73230	137[a]	.04	.08	.14	.06	.04	.13	.04	.21*
Medical/Dental	90010	89	.28**	.16	.39**	.37**	.28**	.27**	.14	..34**
	90230	123[a]	.25**	.23**	.28**	.32**	.19*	.28**	.18*	.15
	90630	X								
Services/Supply	57130	132	.20**	.07	.28**	.14	.18*	.14	.01	.11
	62230	X								
	63130	120	.16	.10	.38**	.09	.20*	.20*	.11	.16
	64730	92	.26**	.18	.36**	.08	.19	.21*	.04	.26**
	81130	714	.16**	.10**	.19**	.13**	.17**	.16**	.07*	.21**
	81230	167	.06	.02	.17*	.09	.10	.05	.00	.22**
	92230	X								
Communications/Operations	25231	X								
	27230	86	.15	.22*	.13	.02	.01	.14	.08	.14
	29130	X								

[a]Insufficient N for cross-validation – total sample used.

[b]X Insufficient Category III and IV personnel for analysis.

*Significant at or beyond .05 level.

**Significant at or beyond .01 level.

Table 7. **Multiple Correlations of Non-Verbal Composite and Cross-Validation Results**

		All Categories			Categories III & IV Only		
			All NV[c]			All NV[c]	
Area	AFSC	N	A[a]	A/B[b]	N	A[a]	A/B[b]
Electronics	30332	99[d]	.25	–	X[e]	–	–
	30430	138[d]	.26	–	X	–	–
	30434	137	.37**	.19*	X	–	–
	32231	145[d]	.37**	–	X	–	–
	32830	100[d]	.38*	–	X	–	–
	32833	126[d]	.53**	–	X	–	–
	32834	99[d]	.51**	–	X	–	–
Mechanical	42132	132[d]	.49**	–	98[d]	.48**	–
	42133	225	.41**	.41**	182	.45**	.29*
	43131	1,147	.29**	.28**	749	.22**	.19**
	43230	371	.37**	.43**	251	.26*	.29**
	44330	81	.39	–	114[d]	.34	–
	46130	284	.36**	.15*	.193	.30*	.04
	46230	305	.23*	.18**	194	.19	–
	53430	98	.49**	.29**	128[d]	.38**	–
	54330	107	.29	–	80	.20	–
Administrative	60530	121[d]	.39*	–	X	–	–
	60531	175	.44**	.37**	116	.36*	.27**
	64530	334	.31**	.21**	204	.29*	.03
	70230	362	.38**	.23**	289	.24*	.23**
	73230	106	.33	–	137[d]	.27	–
Medical/Dental	90010	176	.52**	.43**	89	.50**	.30**
	90230	133	.55**	.42**	123[d]	.37*	–
	90630	116[d]	.37*	–	X	–	–
Services/Supply	57130	194	.28*	.24**	132	.38**	.18*
	62230	112[d]	.32	–	X	–	–
	63130	152	.59**	.44**	120	.44**	.53**
	64730	114	.38*	.44**	92	.49**	.17
	81130	996	.38**	.32**	714	.27**	.34**
	81230	300	.42**	.31**	167	.35**	.23**
	92230	111[d]	.29	–	X	–	–
Communications/Operations	25231	145[d]	.43**	–	X	–	–
	27230	195	.41**	.31**	86	.36	–
	29130	143[d]	.46**	–	X	–	–

[a]"A" corresponds to the validation sample.

[b]"A/B" corresponds to the cross-application of regression weights.

[c]Includes all eight non-verbal subtests.

[d]Insufficient N for cross-application of regression weights, total sample used where applicable.

[e]Insufficient N for Category III and IV analysis.

*Significant at or beyond .05 level.

**Significant at or beyond .01 level.

Predictive Utility of Non-Verbal Battery Versus Selector AI

Before recommending the possible inclusion of non-verbal tests in an operational battery, it is necessary to determine whether the proposed tests add significantly to the prediction of performance criteria over and above the aptitude measures currently in use. To do this, a series of regression analyses were accomplished in which the unique and valid contribution of the non-verbal tests over and above the Selector AI was assessed. Results of these analyses are presented in Table 8, Regression Analysis 1. In 21 of the 34 career specialties, it was found in the all-category samples that the non-verbal tests added significantly to prediction of training performance over the efficiency of the Selector AI used alone.

For the Category III and IV samples, as seen in Table 8, the utility of the non-verbal battery over and above the Selector AI was demonstrated in 14 of the 21 career areas. The results in both the all-category and lower category subgroups appear to indicate that the predictive efficiency of the non-verbal battery is not confined to any specific group of specialties but is generally applicable to a majority of career areas. The widespread utility of the non-verbal composite in a variety of specialty areas further substantiates their potential usefulness in an operational test battery.

The stability of the relationships between the technical training criterion and the non-verbal/Selector AI composites was also determined by cross-validation. The correlation coefficients obtained from cross-application of regression weights to half-sample 2 are contained in Table 9. In the all-category group, composites were significantly related to the criterion in 29 of the 34 courses. Where cross-application was possible, composites maintained their significance in all instances. For the lower category subgroups, 15 of the 21 technical areas had significant composites in the validation sample. In the 12 courses where cross-application was applied, all composites except Materiel Facilities Specialist (64730) remained significant.

Usefulness of Additional Aptitudinal/Educational Data in Predicting Training Performance

In previous research, results concerning the utility of using additional aptitudinal and educational data in the selection and classification process have varied (Brokaw, 1963; Judy, 1960, 1965; Lecznar, 1964). However, findings have generally indicated that data such as educational level and aptitude scores other than the Selector AI demonstrated a significant relationship with performance criteria, especially for lower mental ability individuals. In a recent Air Force study, Wilbourn (1973) found that additional aptitudinal and educational data did add significantly to the operational AIs in many instances.

To assess the predictive efficiency of such data in a larger number of technical areas, regression equations based on a composite of predictor variables including the four AIs, AFQT score, educational level, and the eight non-verbal tests were compared to the equations based on a combination of the Selector AI and non-verbal tests alone.

Results of these regression analyses are presented in Table 10, Regression Analysis 2. A composite of high school graduation status, AFQT score, and AIs other than the Selector AI increased the predictive efficiency over the non-verbal/Selector AI composite in 25 of the 34 all-category and in 12 of 21 Category III and IV courses.

As shown in Table 11, the multiple correlation composites are significant in all but one course, Food Service–Cook (62230), in the all-category samples. All composites remained statistically significant upon cross-validation. While the multiple correlation coefficients were statistically significant in all but two of the lower category samples, in the cross-validation process, two additional composites failed to reach statistical significance.

In this age of high speed computers, individual classification and assignment procedures utilizing multiple predictors is not only feasible but should provide a more cost-effective procedure for assigning enlisted accessions to high cost training programs.

Development of Best Composite for Individual Specialties

Although the potential usefulness of additional data in the classification and assignment system has been established, an optimal composite of predictors for individual specialties was explored. If certain

Table 8. **Results of Regression Analysis 1[a] – Validation Samples**

Area	AFSC	Sel AI	All Categories					Categories III & IV				
			Full Model R^2	Restricted Model R^2	df1	df2	f	Full Model R^2	Restricted Model R^2	df1	df2	f
Electronics	30332	E	.0982	.0181	8	89	.9882	–	–	–	–	–
	30430	E	.0782	.0070	8	128	1.3250	–	–	–	–	–
	30434	E	.1380	.0001	8	127	2.5396*	–	–	–	–	–
	32231	E	.1346	.0000	8	135	2.6253*	–	–	–	–	–
	32830	E	.1752	.0311	8	90	1.9652	–	–	–	–	–
	32833	E	.2771	.0014	8	116	5.5298**	–	–	–	–	–
	32834	E	.2648	.0051	8	89	3.9288**	–	–	–	–	–
Mechanical	42132	M/E	.3277	.2403	8	122	1.9827	.3306	.1298	8	88	3.3001**
	42133	M/E	.1808	.0435	8	215	4.5028**	.2062	.0311	8	172	4.7429**
	43131	M/E	.1312	.0929	8	1,137	6.3039**	.0566	.0195	8	739	3.5256**
	43230	M	.2991	.2573	8	361	2.6901**	.1794	.1457	8	241	1.3286
	44330	M	.1985	.1072	8	71	1.0122	.1397	.0449	8	104	1.4320
	46130	M/E	.2303	.1569	8	274	3.2700**	.1459	.0650	8	174	2.0618*
	46230	M/E	.0934	.1556	8	295	1.5393	.0739	.0369	8	184	.9175
	53430	M	.3360	.2187	8	88	1.9416	.2121	.0875	8	118	2.3341*
	54330	M/E	.2332	.2017	8	97	.4982	.0789	.0508	8	70	.2667
Administrative	60530	M	.2298	.1065	8	111	2.2200*	–	–	–	–	–
	60531	M	.2415	.1008	8	165	3.8238**	.1347	.0035	8	106	2.0092*
	64530	A/G	.1144	.0386	8	324	3.4677**	.0921	.0186	8	194	1.9645*
	70230	A	.1493	.0467	8	352	5.3036**	.0604	.0060	8	279	2.0178*
	73230	A	.1590	.0530	8	96	1.5128	.0860	.0052	8	127	1.4031
Medical/Dental	90010	G	.3614	.2142	8	166	4.7855**	.3178	.1395	8	79	2.5809*
	90230	G	.3586	.1634	8	123	4.6783**	.1743	.5095	8	113	1.9570
	90630	G	.2828	.1779	8	106	1.9383	–	–	–	–	–
Services/Supply	57130	G	.0862	.0173	8	184	1.7342	.1452	.0100	8	122	2.4132*
	62230	G	.1135	.0288	8	102	1.2179	–	–	–	–	–
	63130	G/M	.3687	.0813	8	142	8.0839**	.1904	.0073	8	110	3.1091**
	64730	G	.1439	.0062	8	104	2.0894*	.2408	.0003	8	82	3.2460**
	81130	G	.1560	.0341	8	988	17.8218**	.0815	.0147	8	704	6.3955**
	81230	G	.2665	.1709	8	290	4.7238**	.1838	.0801	8	157	2.4921*
	92230	G	.0854	.0186	8	101	.9466	–	–	–	–	–
Communications/Operations	25231	G	.2804	.1533	8	135	2.9803**	–	–	–	–	–
	27230	A/G	.2178	.0905	8	185	3.7641**	.1673	.0630	8	76	1.1900
	29130	A/G	.2587	.0821	8	133	3.9580**	–	–	–	–	–

[a]Regression Analysis 1: Full model includes Selector AI and all non-verbal tests. Restricted model includes the Selector AI. Hypothesis tested: Non-Verbal tests make no contribution to prediction of final school grade over and beyond the selector AI.

*Significant at or beyond the .05 level.

**Significant at or beyond the .01 level.

Table 9. **Multiple Correlations of Non-Verbal/Selector AI Composite and Stability of Composite in Cross-Application of Regression Weights**

		All Categories			Categories III & IV Only		
			All NV & Sel AI[c]			All NV & Sel AI[c]	
Area	AFSC	N	A[a]	A/B[b]	N	A[a]	A/B[b]
Electronics	30332	99[d]	.25	–	X[e]	–	–
	30430	138[d]	.26	–	X	–	–
	30434	137	.37**	.18*	X	–	–
	32231	145[d]	.37**	–	X	–	–
	32830	100[d]	.26	–	X	–	–
	32833	126[d]	.53**	–	X	–	–
	32834	99[d]	.51**	–	X	–	–
Mechanical	42132	132[d]	.53**	–	98[d]	.53**	–
	42133	225	.43**	.41**	182	.45**	.29*
	43131	1,147	.36**	.39**	749	.24**	.23**
	43230	371	.55**	.54**	251	.42**	.44**
	44330	81	.45*	.43*	114[d]	.34	–
	46130	284	.48**	.28*	193	.38**	.16*
	46230	305	.31**	.30**	194	.27	–
	53430	98	.58**	.46**	128[d]	.38**	–
	54330	107	.48**	.42*	80	.28	–
Administrative	60530	121[d]	.39**	–	X	–	–
	60531	175	.49**	.36**	116	.37*	.29**
	64530	334	.34**	.25**	204	.30	–
	70230	362	.39**	.26**	289	.25*	.24*
	73230	106	.40*	.29**	137[d]	.27	–
Medical/Dental	90010	176	.60**	.49**	89	.56**	.39**
	90230	133	.60**	.52**	123[d]	.37*	–
	90630	116[d]	.37*	–	X	–	–
Services/Supply	57130	194	.29*	.29*	132	.38**	.18*
	62230	112[d]	.32	–	X	–	–
	63130	152	.61**	.45**	120	.44**	.53**
	64730	114	.38*	.44**	92	.49**	.18
	81130	996	.39**	.32**	714	.29**	.35**
	81230	300	.52**	.41**	167	.43**	.30*
	92230	111[d]	.30	–	X	–	–
Communications/Operations	25231	145[d]	.43**	–	X	–	–
	27230	195	.47**	.40**	86	.39	–
	29130	143[d]	.46**	–	X	–	–

[a]"A" corresponds to the validation sample.

[b]"A/B" corresponds to the cross-application of regression weights.

[c]Includes all eight non-verbal tests and Selector AI.

[d]Insufficient N for cross-application of regression weights, total sample used where applicable.

[e]Insufficient N for Category III and IV analysis.

*Significant at or beyond .05 level.

**Significant at or beyond .01 level.

Table 10. **Results of Regression Analysis 2[a] – Validation Samples**

Area	AFSC	Sel AI	All Categories					Categories III & IV				
			Full Model R^2	Restricted Model R^2	df1	df2	f	Full Model R^2	Restricted Model R^2	df1	df2	f
Electronics	30332	E	.4076	.0982	6	83	7.2241**	–	–	–	–	–
	30430	E	.3531	.0781	6	122	8.6432**	–	–	–	–	–
	30434	E	.2105	.1380	6	121	1.8518	–	–	–	–	–
	32231	E	.2006	.1346	6	129	1.7700	–	–	–	–	–
	32830	E	.2589	.1752	6	84	1.5808	–	–	–	–	–
	32833	E	.4750	.2771	6	110	6.9127**	–	–	–	–	–
	32834	E	.4666	.2648	6	83	5.2345**	–	–	–	–	–
Mechanical	42132	M/E	.4641	.3277	6	116	4.9180**	.4904	.3306	6	82	4.2866**
	42133	M/E	.2306	.1808	6	209	2.2569*	.2874	.2062	6	166	3.1492**
	43131	M/E	.2148	.1312	6	1131	20.0512**	.1596	.0556	6	733	15.1213**
	43230	M	.4122	.2991	6	355	11.3828**	.3144	.1794	6	235	7.7098**
	44330	M	.2513	.1985	6	65	.7642	.1800	.1397	6	98	.8043
	46130	M/E	.2720	.2303	6	268	2.5588*	.1989	.1459	6	168	1.8493
	46230	M/E	.1531	.0934	6	289	3.3934**	.1292	.0739	6	178	1.8848
	53430	M	.3962	.3360	6	82	1.3640	.2428	.2121	6	112	.7546
	54330	M/E	.3389	.2332	6	91	2.4245**	.3611	.0789	6	64	4.7121**
Administrative	60530	M	.3215	.2298	6	105	2.3655*	–	–	–	–	–
	60531	M	.3285	.2415	6	159	3.4351**	.2355	.1347	6	100	2.1971*
	64530	A/G	.2643	.1144	6	318	10.7970**	.2408	.0921	6	188	6.1338**
	70230	A	.2745	.1493	6	346	9.9520**	.1574	.0604	6	273	5.2417**
	73230	A	.3199	.1590	6	90	3.5495**	.1743	.0860	6	121	2.1566
Medical/Dental	90010	G	.4308	.3614	6	160	3.2496**	.3831	.3178	6	73	1.2870
	90230	G	.4102	.3586	6	177	1.7065	.2708	.1743	6	105	2.3161*
	90630	G	.3684	.2828	6	100	2.2598*	–	–	–	–	–
Service/Supply	57130	G	.1252	.0862	6	178	1.3232	.1904	.1452	6	116	1.0778
	62230	G	.1286	.1135	6	96	.2771	–	–	–	–	–
	63130	G/M	.4487	.3687	6	136	3.2872**	.3565	.1904	6	104	4.4662**
	64730	G	.1619	.1439	6	98	.4966	.2793	.2408	6	76	.6770
	81130	G	.2040	.1560	6	982	9.8915**	.1143	.0815	6	698	4.3106**
	81230	G	.3671	.2665	6	284	7.5228**	.2458	.1838	6	151	2.0689
	92230	G	.2067	.0854	6	95	2.4214*	–	–	–	–	–
Communications/Operation	25231	G	.3537	.2804	6	129	2.4362*	–	–	–	–	–
	27230	A/G	.2789	.2178	6	179	2.5278*	.3002	.1673	6	70	2.2163*
	29130	A/G	.3440	.2587	6	127	2.7546*	–	–	–	–	–

[a] Regression Analysis 2: Full Model includes ASVAB AIs (M, A, G, E), AFQT score, non-verbal tests, and educational level. Restricted Model includes Selector AI and non-verbal tests. Hypothesis tested: Additional aptitudinal and educational data make no contribution to prediction of final school grade over and above the Selector AI and non-verbal tests.

*Significant at or beyond the .05 level.

**Significant at or beyond the .01 level.

Table 11. **All Variable Composite Correlations and Cross-Validation Results**

		All Categories			Category III & IV Only		
			Composite All Vars.[c]			Composite All Vars.[c]	
Area	AFSC	N	A[a]	A/B[b]	N	A[a]	A/B[b]
Electronics	30332	99[d]	.64**	–	X[e]	–	–
	30430	138[d]	.59**	–	X	–	–
	30434	137	.46**	.39**	X	–	–
	32231	145[d]	.45**	–	X	–	–
	32830	100[d]	.51**	–	X	–	–
	32833	126[d]	.69**	–	X	–	–
	32834	99[d]	.68**	–	X	–	–
Mechanical	42132	132[d]	.68**	–	98[d]	.70**	–
	42133	225	.48**	.46**	182	.54**	.33**
	43131	1,147	.46**	.48**	749	.40**	.35**
	43230	371	.64**	.60**	251	.56**	.60**
	44330	81	.50**	.31*	114[d]	.42	–
	46130	284	.52**	.33**	193	.45**	.21*
	46230	305	.39**	.37**	194	.36**	.32*
	53430	98	.63**	.47**	128[d]	.49**	–
	54330	107	.58**	.65**	80	.60**	.46*
Administrative	60530	121[d]	.57**	–	X	–	–
	60531	175	.57**	.44**	116	.49**	.21*
	64530	334	.51**	.42**	204	.49**	.18*
	70230	362	.52**	.41**	289	.40**	.33**
	73230	106	.57**	.48**	137[d]	.42	–
Medical/Dental	90010	176	.66**	.56**	89	.62**	.27*
	90230	133	.64**	.57**	123[d]	.52**	–
	90630	116[d]	.61**	–	X	–	–
Services/Supply	57130	194	.35**	.35**	132	.44**	.15
	62230	112[d]	.36	–	X	–	–
	63130	152	.67**	.51**	120	.60**	.46**
	64730	114	.41*	.43**	92	.53**	.06
	81130	996	.45**	.37**	714	.34**	.38**
	81230	300	.61**	.45**	167	.50**	.37**
	92230	111[d]	.45*	–	X	–	–
Communications/Operations	25231	145[d]	.59**	–	X	–	–
	27230	195	.53**	.42**	86	.55**	.41**
	29130	143[d]	.59**	–	X	–	–

[a]"A" corresponds to the validation sample.

[b]"A/B" corresponds to the cross-application of regression weights.

[c]Includes all eight non-verbal subtests, AFQT, ASVAB AIs, and Education level.

[d]Insufficient N for cross-application of regress weights, total sample used where applicable.

[e]Insufficient N for Category III and IV analysis.

*Significant at or beyond .05 level.

**Significant at or beyond .01 level.

non-verbal tests or data items do not add significantly to the prediction of the training criterion in a specific course, there is no reason to include them in the final regression equation. This phase of the analysis was designed to identify the most economical composite from the standpoint of the total number of predictors required in the final equation for each AFSC. Only those courses where significant multiple correlations were found in the validation sample were used for this phase of the analysis.

Since the AIs are derived from the current operational test, these four predictors were forced into the composite since no additional testing and no revision to current operational tests would be required if such a composite were used in an operational setting. The remaining predictors which could be selected for the operational composite included AFQT score, the eight non-verbal tests, and educational level. The optimal composite combination of predictors determined by regression analysis varied widely among specialties as shown in Tables 12 and 13. In the Aircrew Life Support (92230) course, the optimal composite includes only three variables in addition to the four AIs. On the other hand, in the Air Passenger Specialist Course (60530), nine additional predictor variables comprised the best composite. In the lower categories, two to nine variables in addition to the AIs were required to develop the best composite.

It is obvious that a tailor-made predictor equation for each specialty is feasible and could be used to refine and improve the current selection, classification, and assignment procedures now in use.

IV. SUMMARY AND CONCLUSIONS

This study was designed to determine the validity of non-verbal measures in the prediction of technical training outcomes and assess the utility of these measures as possible means to refine and improve the Air Force operational selection and classification battery currently in use.

A non-verbal battery comprised of eight subtests was administered to 13,584 non-prior service airmen who were assigned to technical training in 34 different AFSC areas after completion of basic training. Aptitudinal, education, and FSG criterion data were obtained from AFHRL research records.

Correlational and regression analyses were used to evaluate the validity of the individual subtests and composites developed from the non-verbal measures, aptitude scores, and educational data and assess their usefulness in predicting technical training FSG over and above the current operational ASVAB Selector AI. Cross-validation was accomplished where sample size was of sufficient size to permit analysis. In addition to analyses based on the total sample in the 34 AFSCs, separate analyses were accomplished on subgroups of lower mental ability personnel to determine the usefulness of these measures among those individuals who often demonstrate difficulty with the traditionally highly verbal test measures.

The zero order correlations between the individual subtests and FSG were not found to be statistically significant in every technical course. Figure analogies and dial reading appear to demonstrate the highest relationship with FSG in a majority of technical courses in both the total sample and lower ability subgroups. Results indicate that these two subtests are good possibilities for additions or replacements for verbal subtests in future revisions of ASVAB.

The multiple correlations based on a composite of all eight non-verbal subtests reached statistical significance in over 75 percent of the technical areas in the total sample and lower mental category subgroups. Although some of the subtests did not reach a level of statistical significance upon cross-validation, overall results indicate the possible utility of the non-verbal measures is not limited only to personnel in the lower levels of mental ability but might be beneficial for testing all categories of personnel.

Analyses to determine the utility of the non-verbal composite compared to the Selector AI alone revealed that in approximately three-fourths of the AFSC areas, the non-verbal tests made an unique and significant contribution to the prediction of FSG over and above the Selector AI currently used in the selection and classification program. Although some attenuation of the observed relationships between the composite and FSG was also noted upon cross-validation, it appears that the use of the non-verbal tests along with the Selector AI improves the capability to select and assign basic airmen to specialty areas where they are most likely to succeed. When additional aptitudinal and educational data are added to the multiple composite of predictors, the predictive efficiency of the composite increases even more.

Table 12. **Prediction of the Best Composite by Training Course (All Categories)**

		Forced Predictors				Free Predictors										
		ASVAB						NVAB—R								
Area	AFSC	M	A	G	E	AFQT	Educ	Number Reversal	Pattern Matching	Dial Reading	Paired Letters	Wheels	Figure Analogies	Card Patterns	Dominoes	r
Electronics	30332	X	X	X	X	X	X	X	X			X		X	X	.6369**
	30430	X	X	X	X	X	X	X		X	X			X	X	.5900**
	30434	X	X	X	X	X	X						X		X	.4535**
	32231	X	X	X	X		X	X		X			X	X	X	.4425**
	32830	X	X	X	X		X			X			X		X	.4921**
	32833	X	X	X	X	X			X		X	X	X			.6836
	32834	X	X	X	X	X	X	X	X	X	X	X	X			.6807**
Mechanical	42132	X	X	X	X	X	X			X		X	X	X		.6792**
	42133	X	X	X	X	X	X					X			X	.4761**
	43131	X	X	X	X	X	X		X	X		X	X	X		.4633**
	43230	X	X	X	X	X	X				X		X		X	.6410**
	44330	X	X	X	X		X	X			X		X			.4853**
	46130	X	X	X	X	X	X			X	X	X	X	X	X	.5199**
	46230	X	X	X	X	X		X		X	X	X	X			.3892**
	53430	X	X	X	X	X	X						X	X	X	.6254**
	54330	X	X	X	X		X							X		.5771**
Administrative	60530	X	X	X	X	X	X		X	X	X	X	X	X	X	.5657**
	60531	X	X	X	X	X	X	X		X			X		X	.5695**
	64530	X	X	X	X	X	X	X		X		X	X		X	.5125**
	70230	X	X	X	X	X	X	X	X			X	X		X	.5228**
	73230	X	X	X	X	X	X	X			X	X	X	X		.5583**
Medical/Dental	90010	X	X	X	X		X	X	X	X		X	X	X	X	.6557**
	90230	X	X	X	X		X	X		X	X	X				.6354**
	90630	X	X	X	X		X			X			X			.6014**
Services/Supply	57130	X	X	X	X				X		X		X			.3471**
	62230	X	X	X	X		X				X	X		X	X	.3504**
	63130	X	X	X	X	X	X	X	X	X		X	X	X		.6693**
	64730	X	X	X	X		X			X	X	X	X	X		.4060**
	81130	X	X	X	X	X	X			X	X	X	X	X	X	.4514**
	81230	X	X	X	X	X	X			X		X	X		X	.6041**
	92230	X	X	X	X	X	X	X								.4434**
Communications/Operations	25231	X	X	X	X	X	X	X			X		X	X	X	.5930**
	27230	X	X	X	X		X	X		X		X		X	X	.5246**
	29130	X	X	X	X		X	X		X		X	X		X	.5838**

Table 13. **Prediction of the Best Composite by Training Course (Category III & IV)**

Area	AFSC	Forced Predictors: ASVAB M	A	G	E	AFQT	Educ	Free Predictors: NVAB—R Number Reversal	Pattern Matching	Dial Reading	Paired Letters	Wheels	Figure Analogies	Card Patterns	Dominoes	r
Electronics	30332															
	30430															
	30434															
	32231															
	32830															
	32833															
	32834															
Mechanical	42132	X	X	X	X	X	X			X	X		X	X	X	.6980**
	42133	X	X	X	X				X		X			X	X	.5318**
	43131	X	X	X	X	X	X		X	X	X	X		X		.3989**
	43230	X	X	X	X	X	X	X							X	.5580**
	44330															
	46130	X	X	X	X		X	X	X	X	X	X	X	X	X	.4436**
	46230	X	X	X	X	X	X	X			X			X	X	.3537**
	53430	X	X	X	X		X	X	X				X		X	.4870**
	54330	X	X	X	X		X					X				.5831**
Administrative	60530															
	60531	X	X	X	X	X	X	X		X	X					.4812**
	64530	X	X	X	X	X	X	X			X			X		.4871**
	70230	X	X	X	X		X		X	X					X	.3940**
	73230															
Medical/Dental	90010	X	X	X	X		X			X					X	.6108**
	90230	X	X	X	X	X	X				X		X		X	.5148**
	90630															
Services/Supply	57130	X	X	X	X		X			X			X	X		.4285**
	62230															
	63130	X	X	X	X	X	X		X	X	X		X	X	X	.5950**
	64730	X	X	X	X		X	X	X	X	X	X	X	X		.5260**
	81130	X	X	X	X	X	X	X		X			X	X	X	.3375**
	81230	X	X	X	X		X		X	X	X	X		X	X	.4942**
	92230															
Communications/Operations	25231															
	27230	X	X	X	X	X	X	X	X		X	X				.5415**
	29130															

Even though the use of a multi-predictor system for selection and classification poses no technical problems in the age of high-speed, accurate computers, it appears more economical to tailor the composite of variables to each specialty area. This approach would lend maximum flexibility in the use of additional test and/or educational data for classification purposes yet restrict the overall number of variables to only those which make a definite contribution to the prediction system.

These findings substantiate the validity of non-verbal measures and the potential utility of including these measures in future operational test batteries. Since the traditional, highly verbal tests have been criticized for possible discrimination against individuals with disadvantaged backgrounds, lower mental ability, and/or reading disabilities, these tests should not only help to estimate the "true potential" of these disadvantaged personnel but refine and improve the selection and classification system for all categories of personnel.

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